Intel and Quantum Computing

U.S. Government Affairs

Quick facts about Intel

Incorporated in **California in 1968**

U.S.-based manufacturer of **advanced integrated digital technology platforms**

One of the largest U.S. investors of R&D, on average, **investing $13 billion worldwide** or about **20% of annual revenue**.

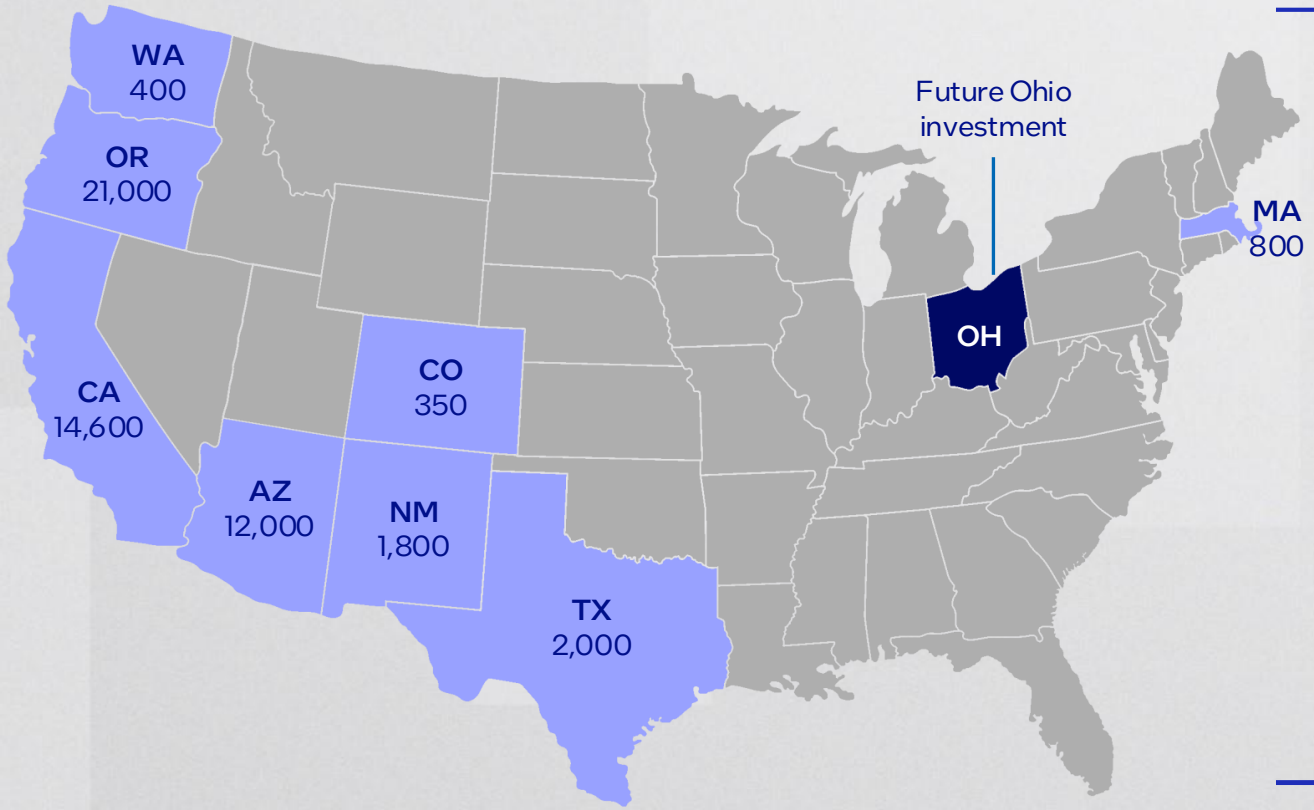
120,000 employees worldwide, with about half located in the U.S. and about **70% are in technical roles**.

Intel has more than **7,000 suppliers** in **46 states**.

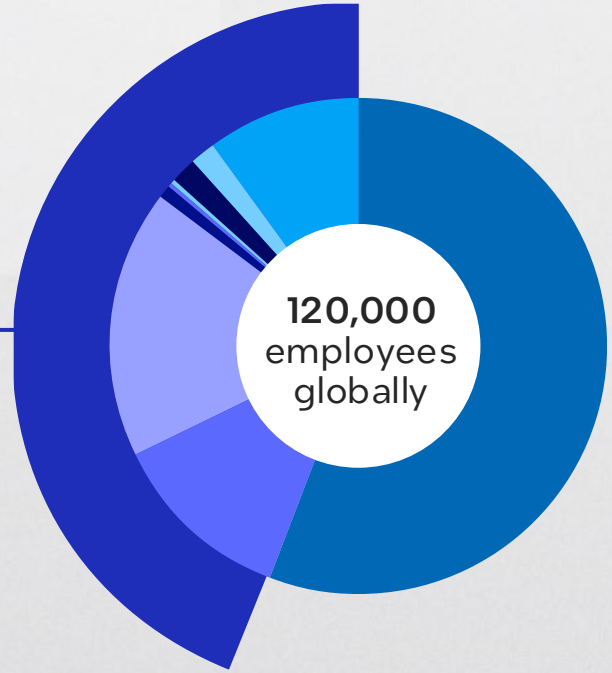
U.S. Manufacturer and R&D Leader

Fun fact

Intel put the Silicon in Silicon Valley, and today our technology remains at the core of the most exciting, life-changing innovations on the planet.



52,950 Intel employees in the U.S.



Intel, Foundries and IDM 2.0

Quick tip

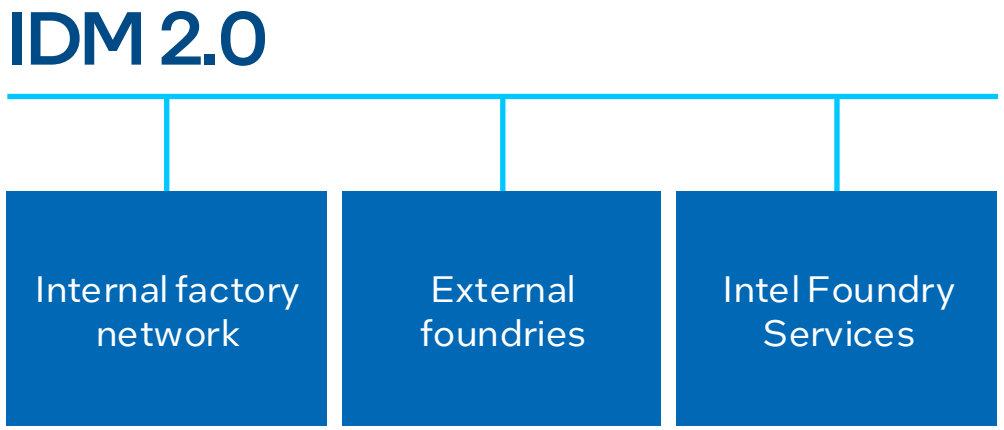
Intel is investing in America with recent announcements to expand manufacturing by $20 billion in Arizona, $3.5 billion in New Mexico, and $20 billion for two new fabs in Ohio.

Semiconductor manufacturers are either:

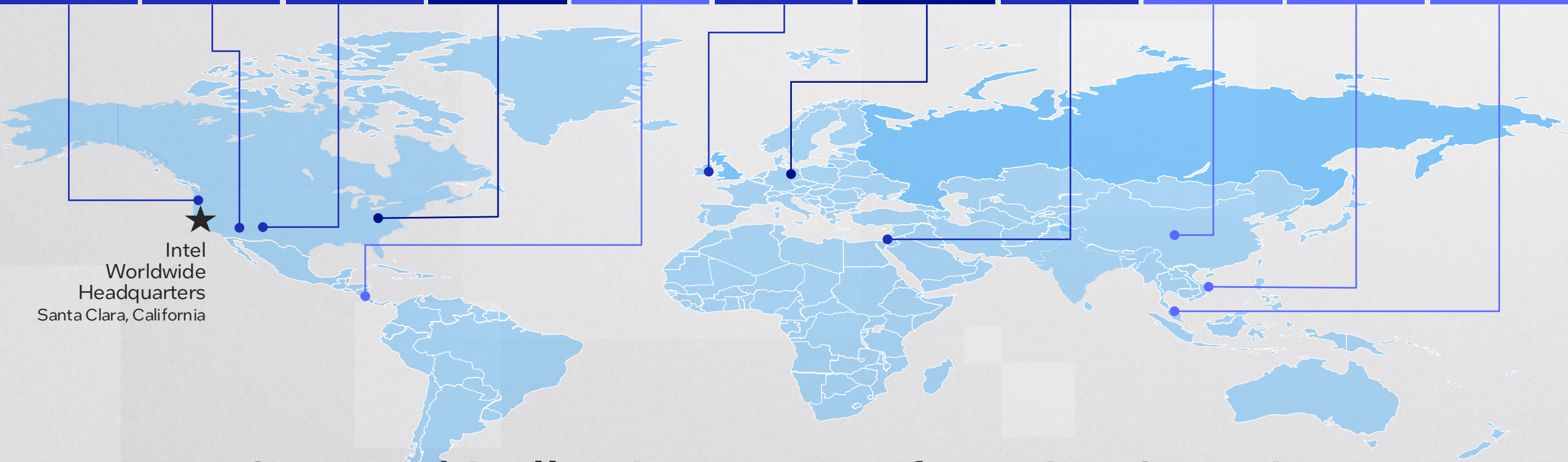
- **Integrated device manufacturers (IDM)** that design, build and sell their own chips; or
- **Foundries** that build chips for "fabless" customers that design, brand and sell them

Intel is different. Its **IDM 2.0 strategy** combines:

- Intel's **internal factory network** to build most of its products
- The use of **external foundries** for flexibility, scale and cost
- **Intel Foundry Services**, a new group dedicated to manufacturing for customers



Intel is the only American IDM with the ability to manufacture advance logic.

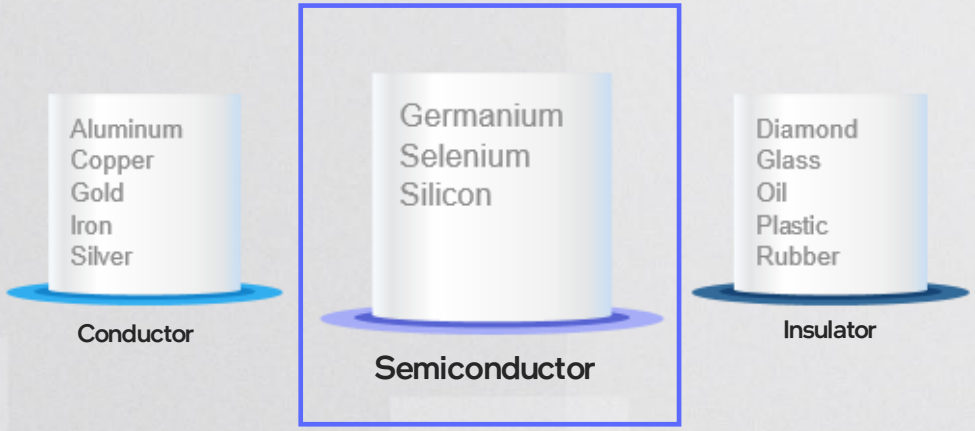


Geographically Diverse Manufacturing Capacity

Wafer Fabs Assembly & Test Future Site

What is a semiconductor?

Semiconductors are essential for the operation of all modern electronic devices.

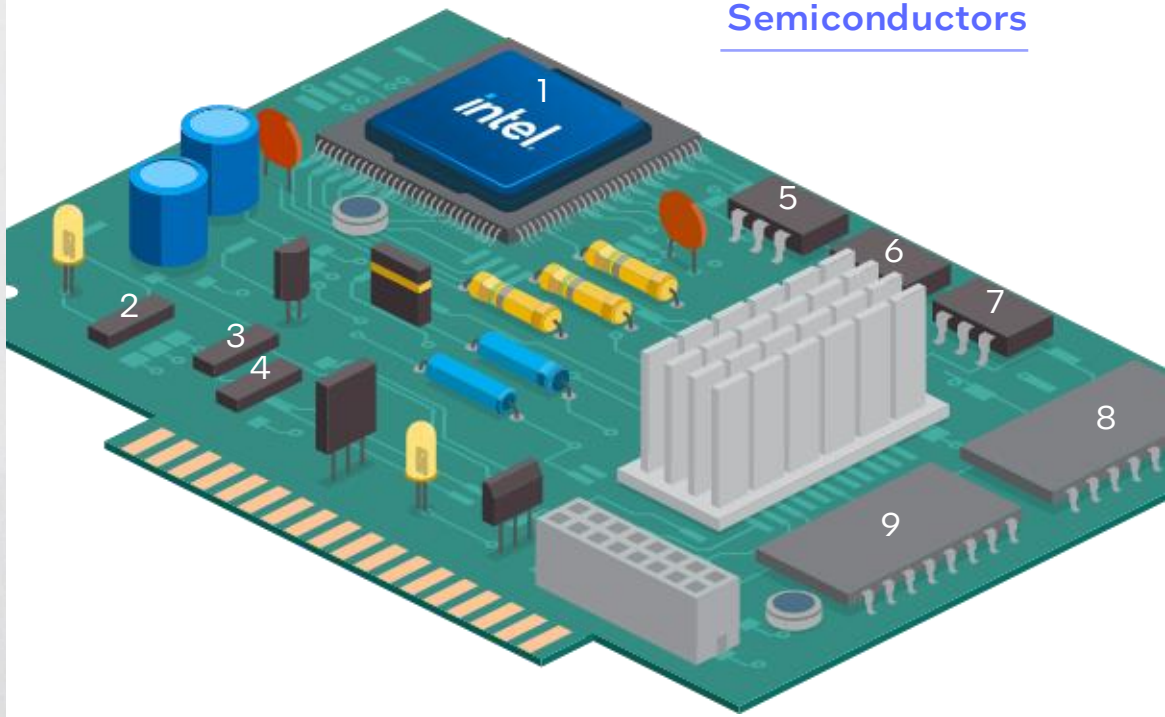


The term “semiconductor” refers to a material that has electrical conductivity greater than an “insulator” but less than a “conductor.” However, it more commonly refers to an integrated circuit (IC) or computer chip. The most common semiconductor material is silicon, the main ingredient of computer chips.

Fun fact

Semiconductors are the critical ingredient of computer chips, which are built for many functions. This motherboard below is showing at least eight of them (the CPU, chipset, memory, storage, BIOS, and input/output chips).

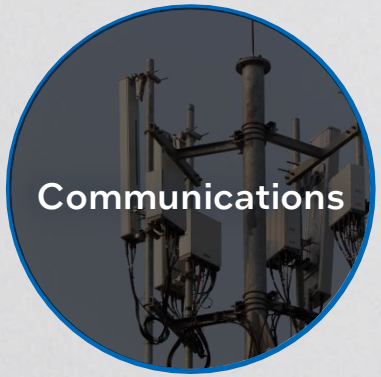
Semiconductors

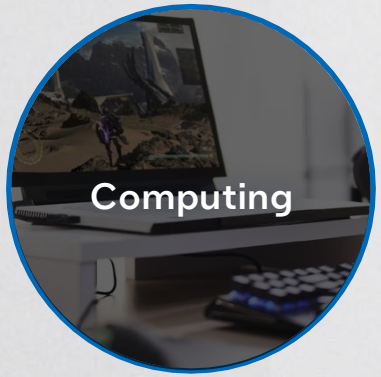


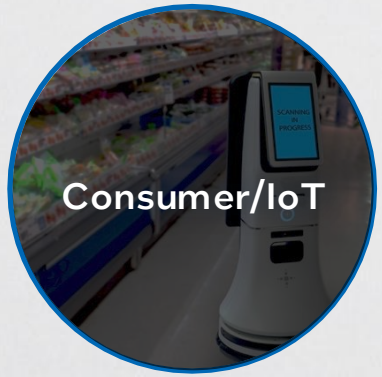
Why are semiconductors so important?

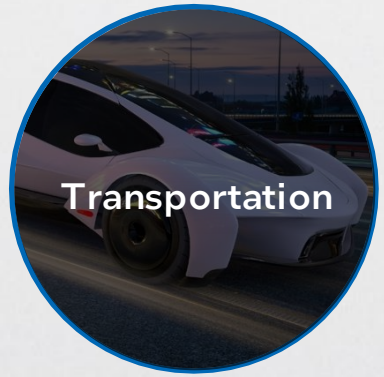
Quick tip

The average American adult spends over 12 hours a day on electronics, such as computers, mobile devices, TVs and cars. Those devices are all powered by semiconductors, which improve our lives, increase productivity and drive economic growth.









$10-15B
The approximate cost to build a new semiconductor factory or "fab"

>6 American Football Fields
Nearly the size of the world's largest semiconductor fab

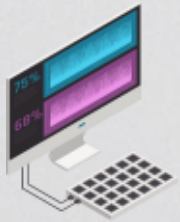
12K
The number of construction, high-tech and support jobs a semiconductor fab typically creates

+$440B
2020 revenue from the global semiconductor industry

How chips are made

Quick tip

A computer chip's journey begins with research. Engineers and scientists from companies and academia develop revolutionary processing and packaging technologies.



1

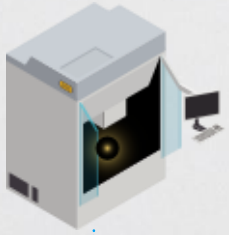
Design

Chip architects, logic designers and circuit designers create computerized drawings (blueprints).

2

Mask Ops

Engineers take the digital blueprints and convert them into glass templates, called masks, which are used in fabrication for photolithography, or "printing with light."



3

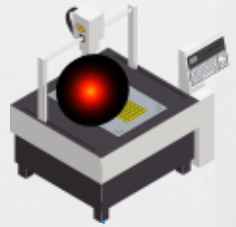
Fabrication

Technicians in bunny suits use a multitude of machines to create layers of circuits and devices on silicon wafers. Each wafer will contain hundreds of chips.

4

Die & Sort

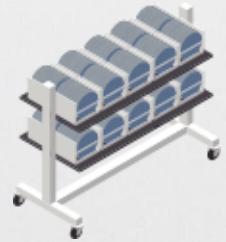
Finished wafers get cut into dies (or computer chips) and placed on reels.



5

Test & Assembly

Technicians test each die one last time, then mount them between a heat spreader and a substrate to form a sleek, enclosed package.



6

Warehousing

Logistics professionals ship out chips to customers or global distribution hubs to be sent to manufacturers or boxed up for retail.

Overview of Intel Manufacturing

Raw Materials

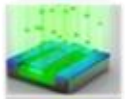
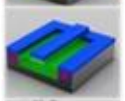
- Sand
- Ingot Slicing
- Melted Silicon
- Ingot

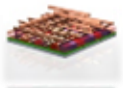



Fabrication (FAB)

- Bare Wafer
- Litho Exposure
- Etch/Implant Films/Planar
- Transistors
- Films
- Metal Layers
- Fab Wafer



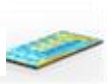
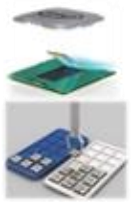






Assembly & Test Manufacturing (ATM)

- Sort Test/Bin
- Cut/Die Prep
- Die
- Assembly



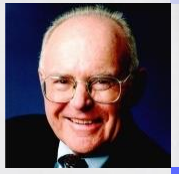
Finished Goods (CPU Example)

- CPU Channel
- Tray (OEM)
- Fan/Heat Sink
- Box Product



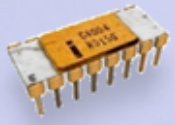

Moore's Law: what it means

Moore's Law was an observation of increasing economic efficiency. In 1965, Gordon Moore made what he later called "a wild extrapolation of very little data" that the number of components per integrated circuit would keep doubling annually (revised later to biannually).

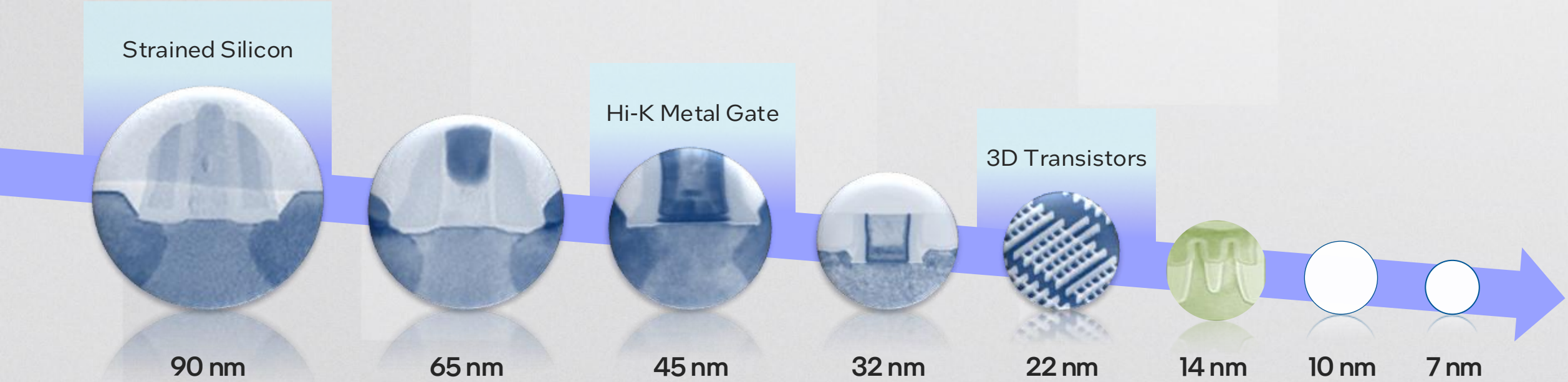


Intel co-founder **Gordon Moore**

Fun fact



Intel's first microprocessor, the 4004, had 2,300 transistors in 1971. Today's have billions. Every process "node" (e.g., 22nm, 14 nm, Intel 7, Intel 4) means improvements in power, performance, area and/or other features.



Why are process nodes so important?

- A smaller process nodes equals smaller die with greater functionality.
- More die per wafer equates to lower cost per die.
- The smaller the die, the lower yield low due to contamination.

Quick tip

A note on node names: Intel introduced a simple and clear naming structure for its process nodes in 2021, one that no longer refers to nanometers. New names include Intel 7, Intel 4, Intel 3, and Intel 20A, ushering in the angstrom era of semiconductors.

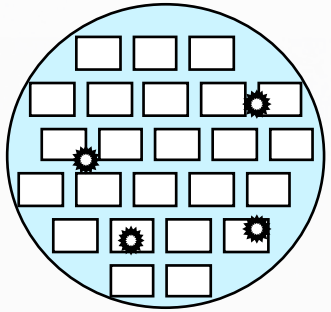
The result of each new process node can include:

1

- **Denser components**
- **Existing functional blocks (IPs) use less silicon area**
- **Many options for better chips:**
  - **Multiply IPs** (more throughput)
  - **Add new IPs** (new features and capabilities)
  - **A smaller overall chip** (lower cost)

2

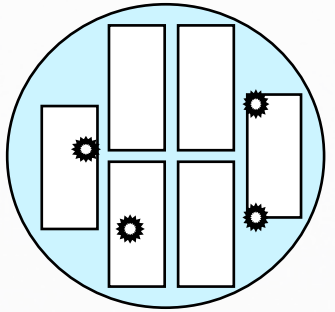
- **More power-efficient and quicker operation,** and/or



Die Yield:
20/24 = 83%

3

- **More dynamic range** (efficient at idle, faster at full throttle)



Die Yield:
3/6 = 50%

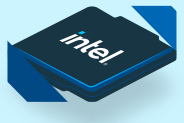
Packaging: protect, connect and re-architect

Connected micron-sized features are on the die to millimeter-sized features on a computer's motherboard, protects the die from contaminants, cools it, powers it, and increasingly, allows multiple die to be combined in novel ways.

New packaging technologies allow the combination of myriad die into "systems in packages," enabling more design and performance flexibility — leading to entirely new kinds of chips, like the powerful Ponte Vecchio GPU.

Intel is a world leader in advanced packaging development and manufacturing.

Quick tip



Intel EMIB very efficiently connects two die sitting side-by-side. Intel's Foveros technology allows vertical stacking of processor die for the first time.

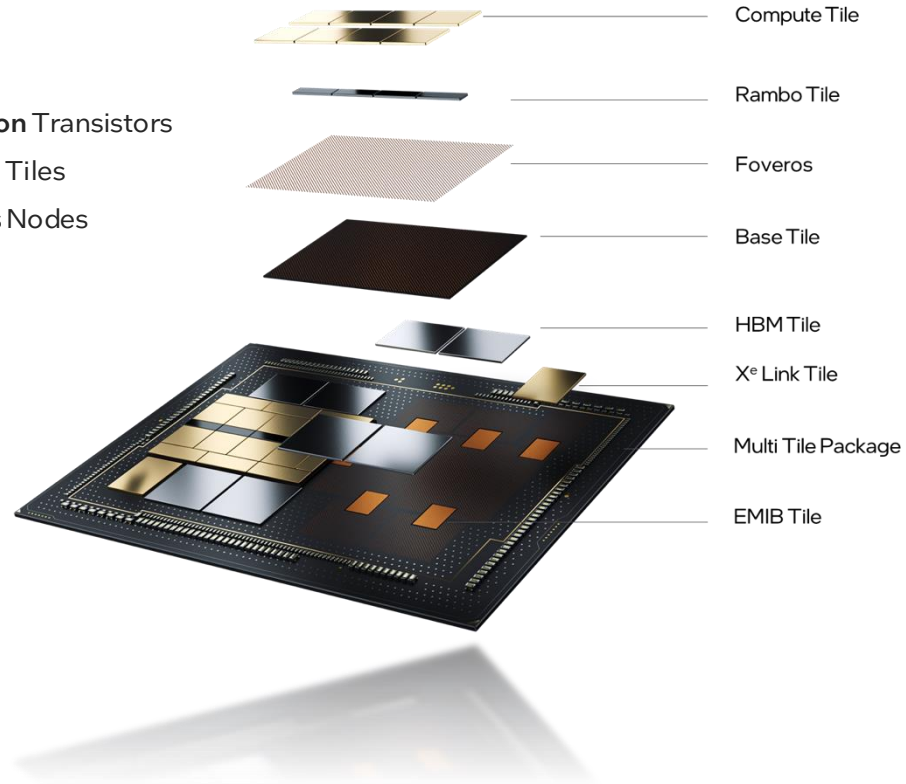
Ponte Vecchio SOC

Advanced packaging enables new era of chip design

>100 Billion Transistors

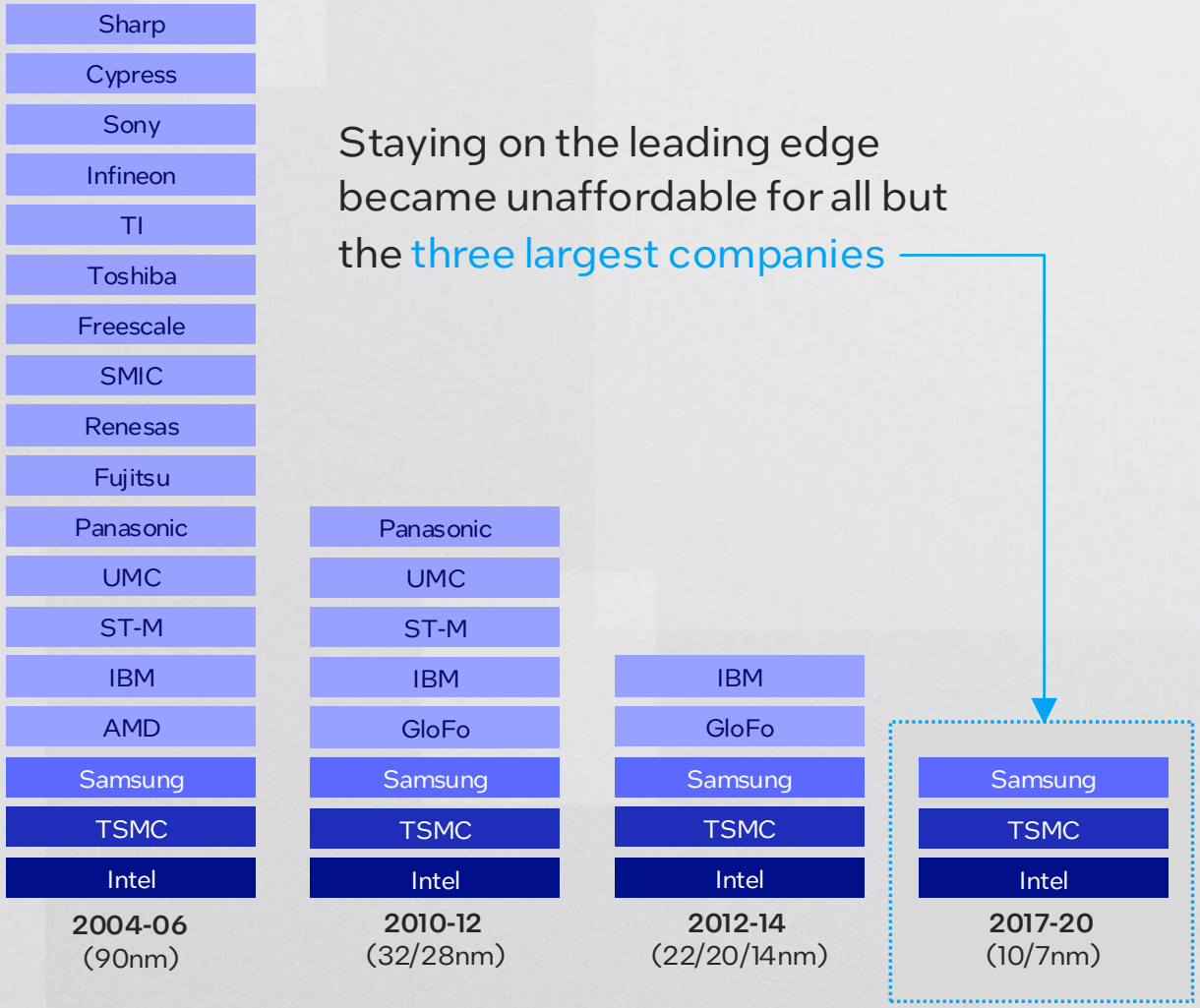
47 Active Tiles

5 Process Nodes

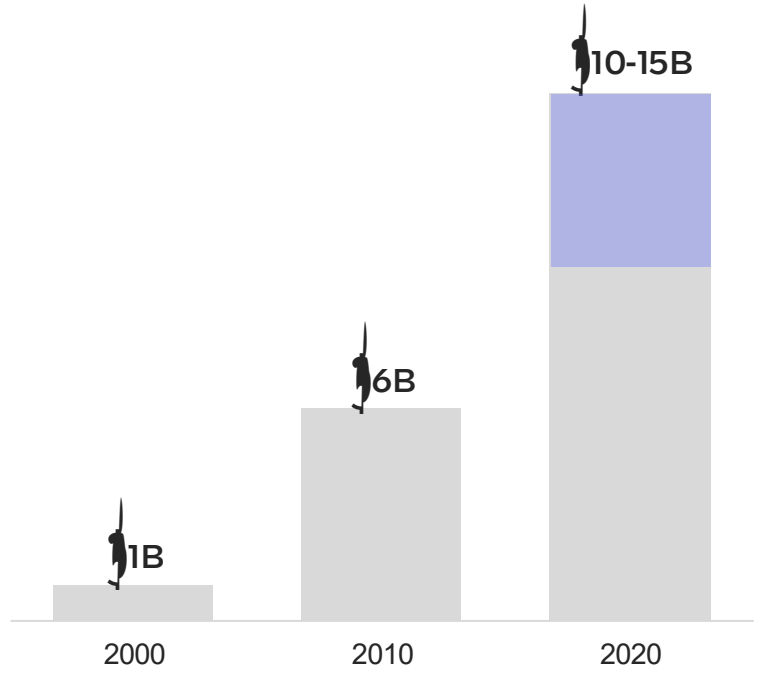


The high cost of manufacturing drives industry consolidation

Staying on the leading edge became unaffordable for all but the three largest companies



The cost to build a leading-edge manufacturing fab



Driving Product Leadership

Client Computing

intel. CORE i9

intel. ATOM

intel. evo POWERED BY CORE i7

Datacenter & AI

intel. XEON PLATINUM

intel. AGILEX

habana® An Intel Company

Network & Edge

BAREFOOT NETWORKS | an Intel company

intel. ARRIA 10

intel® Xeon® D-1600 Processor

Silicon Photonics

Accelerated Computing Systems & Graphics

intel. XEON PLATINUM

Xe HPG

Xe HPC Ponte Vecchio

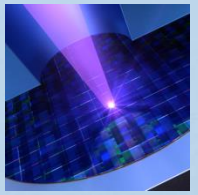
Autonomous Driving

mobileye An Intel Company

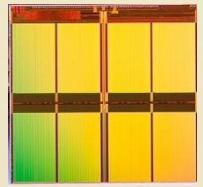
moovit

Mobileye SuperVision™

Foundry Services



NAND Products and Solutions



NAND

intel. OPTANE™

Our Scale

Business

$179 billion
total revenue in 2021

121 thousand
employees work in 53 countries

$15.2 billion
invested in r&d in 2021

Manufacturing

10 Billion
transistors produced every second

100 million
transistors are packed in each mm^2 of a chip

$18.7 billion
in capital investments in 2021

Supply Chain

$1.2 billion
annual spending with diverse-owned businesses in 2020

800+ supplier audits
in the past five years

#1 responsible minerals ranking
for past six years[1]

Community

$38 million
contributed to Intel RISE Technology Initiative

18+ million hours
of volunteer service since 1995

30+ years
of positive impact through intel foundation

Sustainability

94 percent
of non-hazardous waste recycled

7.1 billion
gallons of water conserved in 2020

82 percent
of our global power was green power in 2020

Seeing the manufacturing in action

- https://www.youtube.com/watch?v=aCOyq4YzBtY
- https://www.dropbox.com/s/oujp46uso1qesaw/INTEL_FAB_360_TOUR_OR.mp4?dl=0#
- Inside Intel's D1X: The World's Most Advanced Manufacturing Factoryhttps://www.youtube.com/watch?v=Qo2ywUURSKg

This is Intel

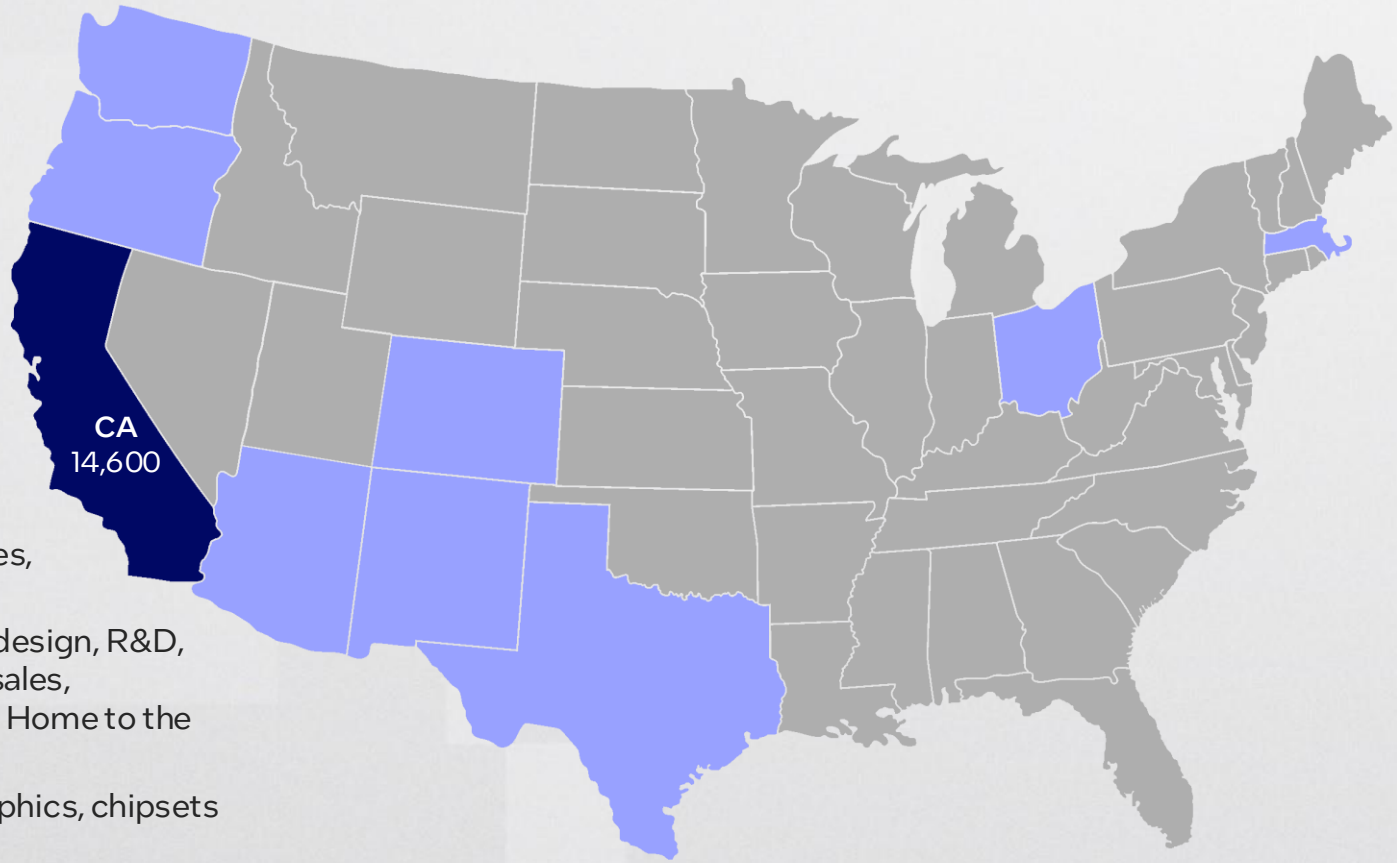

intel

California

Founded in 1968

- For over 52 years, Intel's operations have helped to advance CA's economy
- Total jobs supported 140,000+
- Annual labor contribution $14.2 billion
- Annual GDP contribution $24.9 billion
- Micro wind turbines sit on top of this building, and Folsom solar installation is the largest private solar carport in the country, helping us to achieve 100% green power for our CA energy use.
- Since 2000, Intel has made more than $6 billion in capital investments in CA
- Over last five years, gave $89.5 million to CA schools, universities, and non-profits

- **Santa Clara** (~ 6,000 employees) is involved with engineering, design, R&D, and software engineering as well as corporate functions (legal, sales, marketing, human resources). Mask Manufacturing Operations. Home to the flagship Intel Museum.
- **Folsom** (~ 6,000 employees) is the center of excellence for graphics, chipsets and solid-state drives
- **San Jose** (~1,300 employees) is primarily focused on programmable logic solutions
- **Irvine and San Diego** are research and development sites



Oregon

Est. operations in Hillsboro, 1974

R&D

- World's first 300mm Research and Pathfinding Laboratory
- Employees develop silicon technologies two to three generations ahead of current manufacturing process

Economic Footprint

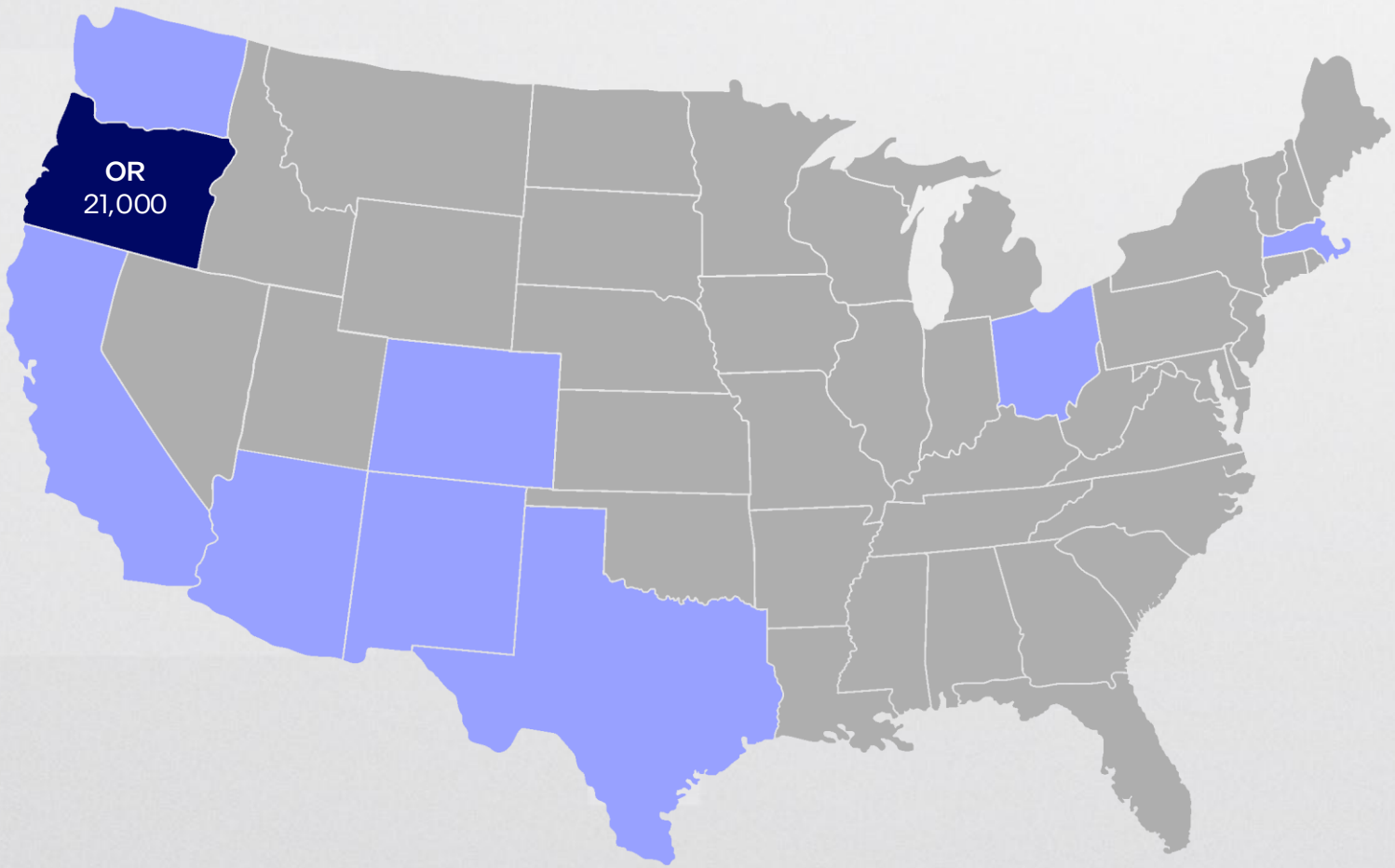
- Activities support more than 100,00 jobs, providing an annual labor contribution of $10 bill and annual GDP contribution of $19.3 billion

Capital Investment

- $49 Billion in capital investment in Oregon to support operations and continued semiconductor fabrication manufacturing

Environmental Priorities

- Intel conserves water within our operation and restores 467 million gallons annually for Oregon. Intel invests in on-site alternative energy and purchase green power to meet 100% of our Oregon energy use



Arizona

Est. operations in Chandler and Ocotillo, 1980

- Manufactures latest products
- Preforms R&D/technology development for assembly and test manufacturing

8.6 billion annual economic impact

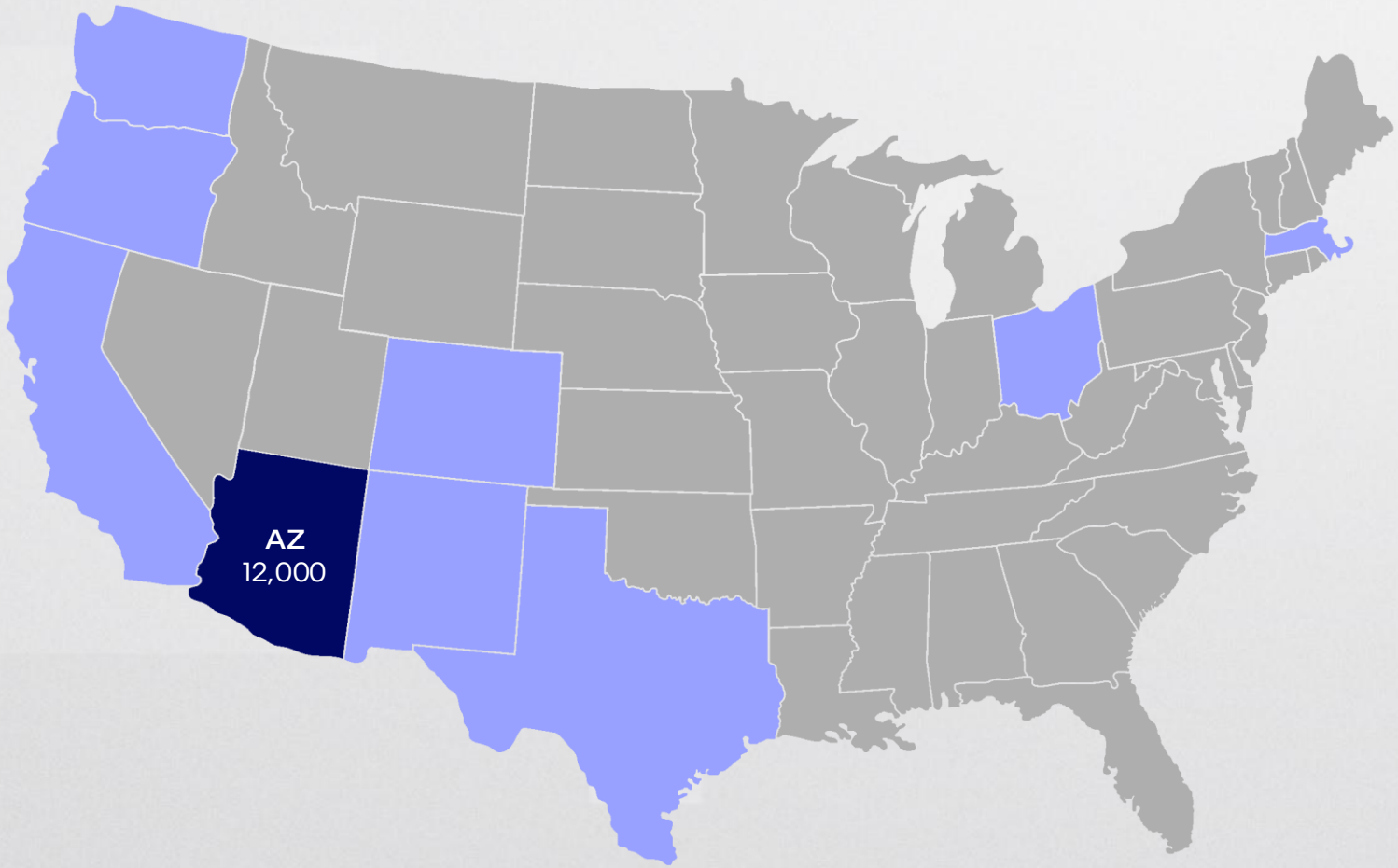
- Activities support more than 55,000 jobs, providing an annual labor contribution of $4.9 billion and annual GDP contribution of $8.6 billion

30 Billion in Capital Investments

- Largest manufacturer in Arizona
- Largest employer in Chandler and 7th largest in Arizona

20 Billion Expanded Investment

- In March 2021, announced $20 billion to build to new factories. Expect to create 3,000 new Intel jobs, 3,000 construction jobs, and indirectly support 15,000 additional Arizona jobs



New Mexico

Est. operations in Rio Rancho, 1980

- Manufactures advanced memory, EMIB and Silicon Photonics.
- Home to Optane Technology Development and NAND Pathfinding and Research Teams

$8.6 billion annual economic impact

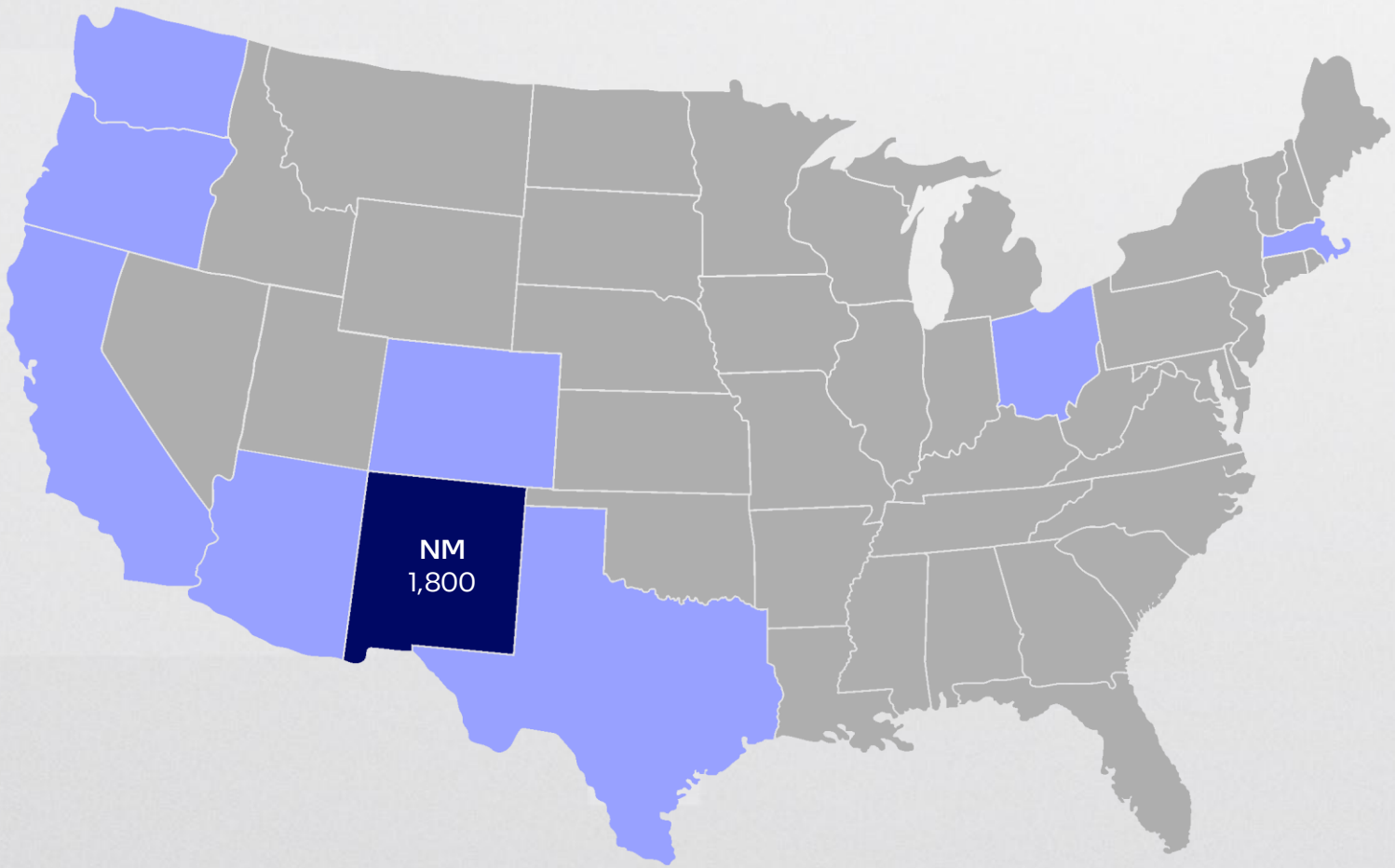
- Activities support more than 9,000jobs, providing an annual labor contribution of $600 million and annual GDP contribution of $1.2 billion

$16.3 Billion in Capital Investments

- Largest industrial employer in New Mexico

$3.5 Billion Expanded Investment

- In March 2021, announced investment to enable advanced semiconductor packaging, Foveros. Expected to create 700 high-tech jobs and 1,000 construction jobs and support an additional 3,500 in the state



Ohio

New operations, 2022

Licking County

- Manufacture leading-edge process technologies and support world-class R&D

Job Growth

- More than 7,000 construction jobs to build initial two factories and initial investment expected to create 3,000 long-term high-paying, high-tech jobs

$20 Billion in Capital Investments

- Two new fabs which is expected to be completed by end of 2025. Largest planned capital investment in Ohio's history

Up to $100 Billion Investment

- At full capacity, the Ohio site could grow up to $100 billion over the next decade